Initial Results of the Denox SCR System by Urea Injection in the Euro 5 Bus

Gabriel Plassat (Data and references April, 2005)

French Clean Buses Programm Evaluation

Initial results obtained on IRIBUS Diesel-powered bus (IVECO engine) with DeNOx SCR Urea system. ADEME methodology is used to quantify the performances and reliability of SCR system on real conditions.

Two major pathways for reducing the NOx are appearing

Euro 4/5: SCR (+ DPF)

• The SCR pathway, prefered in Europe, makes it possible to dissociate combustion optimization and NOx reduction. This solution, moreover, makes it possible to position the NOx/particulates compromise towards low particulates emissions with the NOx emissions being treated by the urea.

US07: EGR + DPF

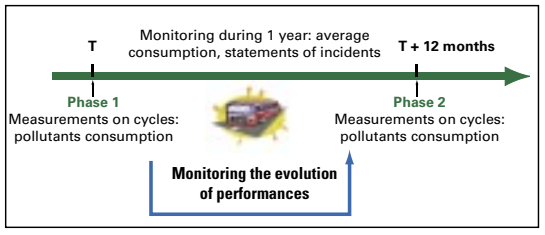
• The EGR pathway, preferred in North America, uses a growing amount of the recirculation of exhaust gas to reduce NOx emissions. The advantage of this solution lies in the fact that it doesn't require additional fluid or the related distribution network.

In the longer term the two pathways will doubtlessly come together. *Source: Renault Trucks/ADEME*

Evaluation protocole from ADEME

The methodology developed by ADEME makes it possible to quantify over a one-year period a technology's performance and to verify its reliability in real use.

A vehicle has already been tested at the UTAC early in the assessment (see the results below) and will again be tested in week 23 of 2005.



Using conditions: near-real circumstances by IRISBUS, i.e. using the vehicle on routes in Lyons (France) but without passengers.

Vehicle technical definition:

- Diesel Engine : IVECO Cursor 8 Horizontal – Dataset Euro 5
- Exhaust : SCR catalytic converter with urea injection

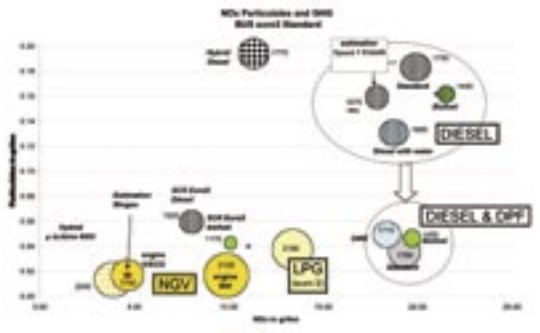
Regulated pollutants and greenhouse gas emissions

➜ Methodology

Obtained on a low-mileage vehicle, then after 7 months of use, these results make it possible to validate this pathway's performances. But they can also be compared to other measurements from the ADEME database. Each pathway (engine/fuel tandem) is typified by these NOx emissions and particulates in g/km on the ADEME/RATP cycle and by its greenhouse gas emissions (GHG) from well to wheel (the circle's diameter filled out by the value in CO_2/km gram equivalent). Ammonia production, a base product of urea, was included at the emissions level of GHG from well to tank with 630 gGHG/liter of urea. It should be noted that the GHG emissions of the ammonia pathway are highly variable depending on the hydrogen production process used (the reforming of natural gas, i.e. 1.15 to 1.3 kg GHG/kg of NH_3, partial oxidation, i.e. 2 to 2.6 kg GHG/kg of NH_3).

➜ Results and discussion

This chart makes it possible to clearly visualize the standard Euro 3 diesel pathway in the upper right-hand corner, then the evolutions provided by an emulsion, Diester, the diesel particulate filter (DPF) or an increase by 5 km/hr of the average speed.



The Euro 5 SCR vehicle, diesel or Diester, enables a reduction in NOx emissions of over 50% compared to Euro 3 in real use. The gas alternatives, NGV or LPG, show similar emissions in terms of NOx and particulates but with remarkable values for the IVECO NGV engine, twice as low.

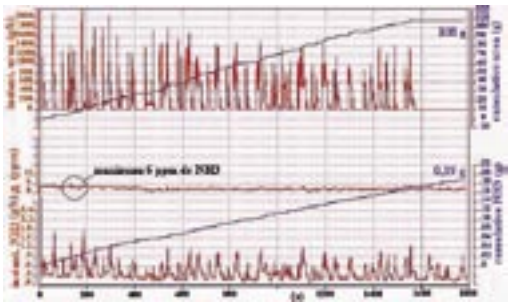
This Euro 5 diesel vehicle stands out for its low emissions of GHG from well to wheel, 13% lower than the best NGV bus (4% being provided by the engine and the rest by the vehicle and the transmission chain). Using Diester accentuates this spread to 33% which only biogas and Hythane are able to compete with.

Urea consumption and NH_3 emissions

The consumption of urea recorded in the two trials is about **4%** of diesel consumption.

Liter/100 km		Urea consumption	Diesel consumption
Agora Line Euro 5 SCR	50 ppm diesel	2.02	50.7
	Diester	2.8	49.7

Consumption of urea in real conditions, in Lyons = 4%.



➜ NH_3 Emission on SCR Euro 5 Vehicle

Ammonia NH_3 emissions were measured on an engine dynamometer during a transient ETC cycle and on a UTAC cycle in the Diester version. During the transient cycle the NH_3 emissions measured in the exhaust are still less than 6 ppm, and the total mass in 30 minutes is 0.19 g, or 0.38 g/hr. The equivalent distance covered on this ETC cycle could be about 15 km (1,800 seconds at 30 km/hr of average speed), or 12 mg/km. **The measurement on the UTAC cycle is 11.5 mg per km for phase 1 and 2.4 mg per km for phase 2.**

Diesel LV	Gasoline LV	LPG LV
0.15 to 0.3 mg/km	10 to 49 mg/km	17 to 96 mg/km

The NH_3 emissions obtained on a bus are therefore on the same order of magnitude as a light gas-powered vehicle.

Assessment and Outlooks

SCR solution system is very encouraging.

Urea additional cost = 0.7 €/100 km

Urea saving cost due to fuel economy = 1.8 €/100 km

Global SCR system saving cost = **1.1 €/100 km**